intended to continue the work of the Coast Survey along this coast; but instead of allowing us to make this voyage empty, some scientific gentlemen were invited by the Superintendent of the Coast Survey to take passage in her, and make the most of the opportunity. Liberal citizens of Massachusetts added means to the good will of the Superintendent—so that whatever collections and investigations should be made during the voyage should not be an additional expense to the great international undertaking, or to the Navy.

"I think it desirable that these facts should be known, in order that not too great expectations should be entertained concerning the scientific results of the *Hassler's* voyage; for all that which could be done was done by means supplied by private individuals, and not by the large resources of the Government. Unfortunately, it is almost everywhere still so, that Science has to take the humblest place in the world, as if equal opportunities were yet granted with a reluctant hand. It is only in recent times that the value of research begins to be felt; and I hope to live, old as I am, long enough to see the community, the enlightened community, which has become my second fatherland, appreciate what Science is doing for the general prosperity, and then contribute to the necessities of Science with that generous liberality which characterises the acts of the American people. It is not generally understood—and perhaps we scientific men are at fault in this matter—that Science is at the foundation of all natural progress in the community, in industry, in the arts, in almost everything."

After a few details as to the objects of the study of natural history, he proceeded to explain that "the only difficulty in the way of the study lies in the fact that there are no teachers; that the community lacks teachers in this department; and wherever there are a few educated, they are at once swallowed by the numerous institutions of learning which are organising everywhere. And we cannot educate a sufficient number of them, for the simple reason that there are other walks in life which are more promising in the rewards they secure for their devotees. So Science is always behindhand, and yet it is she who furnishes the primary material for all the progress in modern times."

We need not follow the speaker through his singular misrepresentation of the theory of evolution as taught in this country, viz., that the various forms of life, as we now see them, "may be the work of blind forces, of forces without intelligence, without discriminating power, and without forethought," and that the object of the study of nature is "to determine whether we ourselves are descended from monkeys or whether we are the work of a beneficent Father." We will rather pass on to his peroration, which sets forth some truths at least as applicable to us as to the audience he was addressing:—

"It will no longer do for the coming generation to say, I will accept this or that doctrine, because knowledge is pressing at your halls: but I will say to you, you may know it because you must know it, and unless you are willing to learn it you may grope in ignorance. That is the condition that stares us in the face for the future, and it becomes on that account the duty of every man to foster knowledge and to prepare the coming generation with all those appliances which lead to an independent opinion on all those matters. And that question is pressed upon you for the first time. You have for the first time in your existence as a State a generation which is about ready to enter the University. You have not had that in past generations, in past years, but your children approach the time when they may prepare for college. It is your duty that you have, then, a college which will set measures of the highest aspiration for the coming generation. And you cannot be willing to depend for their education upon the bounty of other States when in your prosperity, when you have rivalled all civilised communities. When I see luxury here, as in the oldest States of the world; when I see here the appliances for all the efforts of man carried to the highest degree, are you willing that your children should go and beg for information at the doors of other countries? It is for you to educate them and to give them those means which will make them find at home those advantages which otherwise you will have to seek for them by parting with them during those very years when their character is shaping. But there is another consideration than that of your immediate necessities here. No community can be utterly great without culture. Culture is the background of every great community. It is, in fact, the true and only test of real greatness."

Are not we in this country also forcing our children "to go and beg for information at the doors of other countries"? As long as we do not provide at home those educational advantages which so many go abroad to seek, we must submit to have to sit at the feet of our own daughter, and to learn from America both how to honour our really great men, and how to attain that scientific position among the nations to which our wealth and our material resources entitle us. The lesson is hard to learn, but it is one which must be learnt either by us or our children; and the longer we leave the task unlearnt, the harder will it be to learn.

RAILWAYS AND SCIENCE

Life of Richard Trevithick, with an Account of his Inventions. By Francis Trevithick, C.E. 2 vols. (London: E. and F. Spon, 1872.)

Life and Labours of Mr. Brassey, 1805-1870. By Arthur Helps. (London: Bell and Daldy, 1872.)

Railways or no Railways; or, The Battle of the Gauges Renewed. By Robert F. Fairlie. (London: Effingham Wilson, 1872.)

THESE three works are directly concerned with railways, though each of them deals with a different aspect of the many-sided subject. It would be out of place in these columns to review in detail each of the publications; they may, however, suggest a few thoughts not inappropriate to the columns of a scientific periodical.

The first on the list takes us back to the birth of the steam-engine, carrying us on through its chequered and roughly-handled youth to the time when it was fairly set agoing on that wonderful career, by means of which the whole face of the earth has been changed as if by the breath of a god, the relationships of nations and of men altered entirely, and civilisation hurried on at a rate almost bewildering. The benefits conferred on humanity by the discovery of the simple scientific principle on which the steam-engine rests, are incalculable, and not to be realised in anything like their fulness by those who, like most now living, have been born to these benefits, and who can only grumble that the advantages of the legacy left them are not by any means what they might be, were they not marred by the officiousness, the avarice, the prejudices, and the blundering stupidity of those who have constituted themselves its trustees. That this has been a cause of complaint all along is one of the many lessons to be learned from Trevithick's life; and so will it ever be, until the simple but stupendous and widely beneficent principle which the man of science, by reverent asking, has obtained from the liberal hand of Nature, is not only more thoroughly understood and more scientifically applied by those who undertake to put it to the uses of humanity; but until Science holds supreme sway over all the actions and thoughts of men universally, until she holds the same place as a guiding principle for the lives of men, and their relationships to each other and to the surrounding universe, that superstition and wild imagination have held for ages. It will only be when education is founded upon a thoroughly scientific groundwork, when men are trained from their youth upwards to regard human and extra-human phenomena with the clear, bold, intelligent vision of science undimmed by superstition, unwarped by prejudice, and unshortened by selfishness, that the full significance of scientific discoveries will ever be realised. Only then will they have a chance of making unobstructed way in conferring upon mankind the innumerable benefits with which many of them are fraught, and in raising the race higher and higher in the scale of civilisation, till that golden age be realised which poets dream of as in the unknown past, but which assuredly lies in the certain though, it may be, far distant future.

These remarks are suggested by the "Life of Trevithick," which, read in the light of the present day, makes one feel somewhat sad, and certainly sorry for the great and unselfish mechanical genius who scattered his inventions broadcast among his fellows, to the great enrichment of the latter, while he himself led a chequered and almost homeless life, dying, at last, penniless among strangers. Trevithick himself was not a scientific man, and seems to have had only a vague notion of the scientific principles upon which his numerous applications of the expansive power of steam were founded. But he was not like many so-called "practical" men, who work only by rule of thumb, and profess contempt for the scientific principles which they put to practical use. Trevithick appears to have had the greatest respect for science, and invariably submitted a new invention, or application of the one simple principle which governed all his inventions, to his scientific friend Mr. Giddy (afterwards Gilbert, and President of the Royal Society), in order that they might be submitted to the rigid test of scientific theory. Had a similar course been followed at a much earlier period, and had the earlier manipulators of steam been animated by the same spirit as well as the enthusiasm, and penetration, and disinterestedness of Trevithick, the steam-engine, instead of remaining the clumsy and unpliable machine it did for so many years, might about a century and a half ago have reached the perfection and wide applicability it has attained at the present day. And it was only in proportion as mechanicians clearly realised for themselves the full significance of the simple laws of steam, and fearlessly allowed them, under judicious control, to work with a powerful purpose upon properly constructed machinery, that anything like the wide-spread benefit was derived from them that they were calculated to confer; in other words, it has only been in proportion as engineers have grounded the rules of their art upon scientific principles that the steam-engine has attained to its present comparative perfection and innumerable labour-lessening and therefore blessed uses. In this it is that the great merit of Watt and Tevithick lies, both of whom had the penetrative genius to perceive that the mighty power which lies latent in a cup of water was almost entirely frittered away for want of proper guidance and a suitable channel wherein to work; and within a very few years after these men had made their important inventions, the development of the steam-engine had made infinitely more rapid progress than it had done during a previous century,

The history of the application of steam to machinery, the gradual development of the steam-engine, and especially its use for locomotive purposes, must be known to all our readers, and therefore we shall not attempt to repeat the oft-told story. It is one of those "fairy tales of science," which are more wonderful and often more bewitchingly beautiful than any of the thousand myths by which our "rude fore;athers" blindly but naturally attempted to explain the many mysteries of the universe; and they have the additional merit of being true and therefore undying and never leading to disappointment and distrust. Nor shall we attempt to adjust the relative claims of Watt and Trevithick to priority of invention, or try to show their respective shares in the discovery from which the world is now reaping so much benefit. It is humiliating to think that Watt and Trevithick lived for a considerable time only a few doors from each other in a small Cornish town, each bent upon accomplishing a beneficent and highly useful purpose, and yet never spoke to each other, but on the contrary regarded each other with considerable bitterness all their lives; and this simply because the one advocated high pressure while the other was pushing the adoption of low pressure engines. Mr. Francis Trevithick, naturally enough no doubt, but with very bad taste and we believe much injustice, speaks of Watt frequently with great bittterness and depreciation as his father's rival, and jealous and ill-speaking opponent. To revive these squabbles serves no good purpose, but merely gives occasion to the world which lies in ignorance to sneer; the merit of Watt was very great, and so was that of Trevithick, and there is no need whatever to exalt the one at the expense of the other; each has a lofty and enduring pedestal of his own. We also think it displays considerable want of reflection and of the philosophic spirit to tirade, as Mr. F. Trevithick does, against the ingratitude of mankind towards those men who have conferred upon them great benefits in the shape of useful inventions, and against the deafness of men in place and power towards their claims for assistance and reward. The fact is that all great inventors, like all men of supreme penetration and foresight, are often too far in advance of their own generation to meet with much sympathy and appreciation from it. Mankind are not to be sweepingly blamed for this on any score. The race is yet a long way off perfection; and if the world ran so close on the heels of its great men as to be able at once to comprehend and appreciate them, these men would not be so great after all. The world, on the whole, acts very honestly, however hardly, to her man of genius, and when she does reach his standpoint, she erects a monument to him if he be dead, or if happily he be still alive, she rewards him with a pension. That Trevithick should have died penniless was pretty much, we think, his own blame, attributable to his own reckless imprudence, and his decided and blameworthy weakness of character in being unable to manage the affairs of his own household. It was no merit in him, and no sign of unselfishness, but simply a defect in his character, as it is in that of all men who act as he did.

That Trevithick is entitled to be called the "father of the locomotive" there seems to us to be no doubt, from the tediously full statements in the biography by his son; not only so, but he conceived and sketched, and even modelled, many of the improvements, perhaps in a crude form, that have been most recently introduced. In 1796 he made a model of a locomotive; in 1801 he ran one on a rough common road in Cornwall; and in 1803 he astonished the Londoners early one morning by driving the then uncouth creature through ten miles of the streets of the metropolis. Trevethick, however, reaped little benefit or credit from this wonder-working invention, for which the world at the time was not ripe. Of the numerous other applications of steam which Trevethick either thought of or embodied, we may mention the principle of the screw-propeller, the steam dredging-machine, the application of the steam-engine to an infinite variety of purposes in mining and tunnelling, the invention of something very like the borers used in the Mont Cenis tunnel, and the application of steam to nearly every important agricultural and manufacturing process; indeed he actually constructed several thrashing-machines, which many, no doubt, consider quite a recent invention.

It is by reading a biography like this, which takes us back to the middle of last century, and brings us down to nearly the middle of the present, that we are able in some small degree to estimate the benefit which science has conferred upon man in discovering the great but simple principle which underlies every application of steam as a moving power. Not only has it in almost every direction brought manufacturing processes to the highest degree of perfection, increased almost infinitely the power of production, but it has been the means of lessening, directly or indirectly, the severity and the amount of manual toil, thus making the mechanic's life sweeter and easier, and leaving him leisure for self-culture; and in general advancing to a distinctly appreciable amount the civilisation of the race. Especially, as we have already said, has the whole face of the earth been changed by the application of steam to locomotion; and even in this one direction it would be difficult to estimate the benefits conferred upon the race by science. The traint and the steamer have done much to lessen and stamp ou old national and district prejudices and animosities, by making the men of various nations more thoroughly and generally known to each other, have enabled populations to circulate more freely, and men to bring their talent or their craft to the market where it was most in demand, have made emigration possible to almost all who care for it, and thus peopled and civilised the waste and barbarous lands of the earth, brought the products of the most remote quarters within easy reach, brightened the existence of many thousands by putting it in their power to see some of the many beauties of this lovely earth—made the world, in short, more manageable, drawn its inhabitants closer together, increased decidedly the sum of human happiness, and helped to bring on the time "when man to man the warld o'er shall brithers be, and a' that."

As to the manner in which Mr. F. Trevithick has written his father's life, we are sorry we cannot speak favourably; either he does not know how to write biography, or he has been either so lazy or so short of time as to give to the public the crude and tedious material out of which a biography might have been constructed, instead of a well-digested and clearly-arranged narrative. The two volumes number upwards of 750 pages, and we believe not 50 of them are Mr. Trevithick's own. It is one of the most confused, most ill-put-together books we were ever compelled to read, and were it not for the intrinsic interest of the subject, it would certainly be the most tedious. The illustrations, type, and paper are excellent, and the book will no doubt be found useful by engineers

The next book on the list, Sir Arthur Helps's "Life of Mr. Brassey," is, it is needless to say, as a work of literary art, infinitely superior to the former, though the subject is one of not nearly so great intrinsic interest and importance. Had the work of writing the life of Mr. Brassey fallen into any other hands, it might have been a very dull and uninstructive affair indeed; but it is impossible for the author of "Friends in Council" and "Thoughts upon Government" to write uninterestingly or inartistically about anything. This life of the great railway contractor has all the quiet and soothing charms of Sir Arthur Helps's well-known style; and dry as the subject looks at first sight, it is full of interest and novelty, of details that few are acquainted with, and which are yet well worth knowing. The book is worth publishing, were it for nothing else than to make the world acquainted with a man of the late Mr. Brassey's exceptionally superior character and great power of organisation; indeed the author tells us that it is as an example of skilful organisation that the life of Mr. Brassey has especial interest for him. We do not intend to give any sketch of the life of the great and universally loved and respected railway contractor; his life, in one sense, takes up the story of the steam-engine where Trevithick's leaves it off. Trevithick and such as he show how steam may be applied to the purposes of locomotion, which brings into play a new set of men, a new profession, as it were, that of contractor, whose business it is to see that suitable roads are made for this horse of man's creation to run upon. That this may be done it is necessary for the contractor to procure an army of navvies and others, officered by all grades of superintendents, from the ganger up to the sub-contractor or agent. Of how much importance careful organisation is in a case like this must be seen by every one, and of as much importance is it that every one, from the engineer and contractor down to the ganger should have a thorough and intelligent—in other words, a scientific knowledge of the department of which he has immediate charge. This was what distinguished Mr. Brassey above many others in his position; he did not work merely by rule of thumb, but raised the business of contractor almost to the dignity of a science; and the thoroughness which was the result of this, combined with the man's noble character, obtained for him the great reputation and extensive employment which he all along possessed. One lesson which this work teaches above others is that the better educated, the more intelligent, in short, the more scientific, are all, from the highest to the lowest, who are concerned with the practical carrying out of the application of any scientific principle, the more thoroughly and satisfactorily will the work be performed.

The author does not say much—indeed little could be said—about Mr. Brassey's personal life, the greater part of the book being occupied with exceedingly interesting and varied details as to railway construction. Mr. Brassey, as a contractor, we believe, was more or less intimately connected with the construction of many thousand miles of railway in all parts of the world—Europe, Asia, North and South America, Australia—thus bearing a large share in carrying one of the greatest blessings science has conferred upon humanity, to all the ends of the earth. Not only was the railway itself a great benefit to the country into which it was brought, but the mere process of construction was a boon to thousands of its inhabitants. There are extensive districts in France in which the material prosperity of the inhabitants has been permanently raised by the savings which the French labourers realised at the construction of the Paris and Rouen railway. With whatever railway, in whatever country, Mr. Brassey had to do, he always liked to have the principal work done by English navvies; this was even the case in Canada; and some of the most interesting pages of the biography are those in which the railway labourers of other countries are contrasted, in point of character, powers of work, &c., with those of England. Taking them all in all, the latter cannot be beaten for quantity and quality of work. Sir Arthur Helps adds a chapter on "Railways and Government Control," in which he seems to think that it is now high time for Government to take the railways out of the hands of ignorant, irresponsible, conscienceless speculators, and work them itself solely for the public good, which is the last thing thought of by the present managers. One sentence is worth quoting here; we wish we had room for more:—"It has always appeared to me to be one of the most miserable instances of the hide-bound nature of our official system, which is hampered by so many checks and so much dread of small expense, that the most needful undertakings have to be passed by, or touched but lightly, which require the best intellectual force of the nation to be brought to bear upon them."

Mr. Fairlie's book, "The Battle of the Gauges Renewed," proves the truth of what we have already said—the necessity there is that all who are officially connected with railways should be able to perform their work on the basis of scientifically-grounded knowledge, and not in the light of tradition and custom, by unintelligent rule-of-thumb. Both by Mr. Herbert Spencer and Mr. George Darwin it has been recently pointed out that the construction of our railway carriages, instead of being based on a rational attempt to adapt them to new and previously undreamt-of circumstances, is simply a continuation, or rather development, of old forms belonging to the lumbering stage-coach and rude tramway days. That it is so with regard to the common gauge of wheels (4 ft. 8½ in.) is well known, though one would at first sight be inclined to believe that the odd half-inch was significant that this gauge was the result of a careful calculation grounded on the best mechanical principles. That this is not so can be learned from Mr. Fairlie's vigorous, clear, and, notwithstanding the apparent dryness of the subject, really interesting book. When railways were first constructed, about forty years ago, men were too much absorbed in the excitement of the new means of locomotion to give any thought to such an apparently trifling detail as the width that should be maintained between the two rails; and thus the gauge which was in general use among the old and rudely constructed tramways was adopted at mere haphazard, without any thought as to whether there was any good reason for adopting the 4 ft. 8½ in. How old the gauge is, and how it originated, probably no one knows, though we believe that even now not a few railway directors, and even engineers, will be found who maintain that it is a heaven-born institution, and that to alter it would be the height of irreverence and sacrilege, betraying an independence of thought and action worthy only of a nation like America, destitute of tradition. It is not our purpose here to advocate any one gauge as preferable to another, but simply to say that one lesson taught by the three books at the head of this article is, that the present condition of our railways is, to a large extent, the result of mere guess-work, and that only when the construction of every detail, from the steam-engine down to the gate at a crossing, or a pointsman's box, is conducted on rational, *i.e.* scientific principles, can the public, as well as the shareholders, be able to reap without drawback all the advantages which the great application of the power of steam is calculated to produce. On every ground it seems difficult to resist Mr. Fairlie's arguments on behalf of the 3 ft. 6 in. gauge, or even a narrower gauge under certain circumstances; it has been extensively adopted in America, and exclusively in Norway; and, we dare say, most people would be astonished to hear that at Festiniog, in Wales, on the face of a steep mountain, with gradients of 1 in 68 and 1 in 79, and with curves varying in radius from 8 chains to 1¾ chains, there has been at actual work for some years a railway with the miniature gauge of 1 ft. 11½ in. "It is, in fact, the most perfect miniature railway in existence, and deserves to be studied in all its details." Both as a passenger and mineral railway, it has done hard and perfectly efficient work for some years. This, at least, shows that the question of "gauge" is worth being inquired into, as indeed ought every other point connected with the construction and management of railways.

The revelation which results from one inquiry after another, and the harrowing effects of the dreadful accidents which are almost daily occurring, will doubtless have their effect on the public mind, and urge the people of this country either to compel Government to take the railways into their own hands, or, at least, to see to it that they are managed in some kind of rational and intelligent way, for the good of the public, and not for the sole benefit of a few obtuse directors.

M. de Quatrefages, in his opening address at the meeting of the French Association, was too sanguine when he said, "Science is at present supreme," though we believe he was right in asserting, "She is becoming more and more the sovereign of the world;" and only when Science reigns supreme over all the practical affairs of men, shall we be on the high road to perfection, in this direction at least.